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Transmission of *Sarcocystis* to swine. L. A. SPINDLER, HARRY E. ZIMMERMAN, JR., and DANIEL S. JAQUETTE, U. S. Bureau of Animal Industry.

STATEMENT OF PROBLEM

Parasites classified in the genus *Sarcocystis* are found chiefly in the striated muscle tissues of mammals, birds, and reptiles, where they occur in the form of elongate bodies known as Miescher's sacs. Among the mammals, Miescher's sacs are known to be especially common in swine, cattle, and sheep, as many as 100 per cent of these animals being infected in some localities (Ostertag, 1904; Bergmann, 1913; Alicata, 1932; Scott, 1943, and others).[1] In spite of the widespread occurrence of *Sarcocystis* in food animals, the life cycle has not been well understood because of the occurrence in the literature of contradictory views and opinions concerning modes of transmission. For example, some investigators, among whom are Smith (1901) and Darling (1910), concluded that infection occurs as a direct result of ingestion of flesh containing mature Miescher's sacs. While this hypothesis would explain transmission in the case of carnivorous and omnivorous hosts, it does not adequately account for the widespread occurrence of *Sarcocystis* in strictly herbivorous animals.

In contrast to the views of the investigators named, Behla (1897), Galli-Valerio (1913), and Scott (1915) failed to transmit *Sarcocystis* by feeding infected flesh, and Minchin (1903), Creech (1922), and Scott (1943) expressed the opinion that carnivores probably serve as "intermediate hosts" for the dissemination of the parasites to herbivores. The latter hypothesis found support in the work of Négre (1907, 1910, 1918) who reported experimental transmission of *Sarcocystis* to mice by feeding feces of other mice that had previously eaten infected mouse flesh. Transmission by this means was not effected, however, by Négre until 15 or more days had elapsed after infected meat had been consumed. On the basis of his findings Négre postulated that an intestinal stage of *Sarcocystis* developed in the mice after ingestion of infected flesh. Scott (1915), on the other hand, was unable to confirm these findings. Scott permitted lambs to pasture on grass plots that had been occupied for a time by dogs fed flesh of naturally infected sheep; the sheep so pastured did not acquire *Sarcocystis*.

In view of the widespread occurrence of *Sarcocystis* in the flesh of animals used for food, and the lack of specific information on its mode of transmission, an investigation was begun by the authors of this paper to obtain information on the transmission of *Sarcocystis* to swine. The investigation was designed to ascertain (1) whether infections of *Sarcocystis* can be produced in swine and other animals by feeding flesh of infected hogs; (2) whether infections can be induced in swine by feeding to them feces and urine eliminated by these host animals after consumption of infected flesh; (3) how soon, after consumption of infected meat,

[1] Space is not available in this publication to cite and review the extensive literature pertaining to observations and investigations on *Sarcocystis*. Consequently there will be cited only a few references considered pertinent to an understanding of the investigation herein reported. For a recent review of the literature the reader is referred to the publication by Scott (1943) included in the list of references cited at the end of this paper.

transmission through the feces and urine would occur; and (4) the clinical and pathologic effects of the parasites on the host animal.[2] It was believed that an investigation of this kind would throw light on the life history of *Sarcocystis* of swine and other hosts.

EXPERIMENTAL PROCEDURE

Sixteen experiments were carried out, 14 of which are summarized in the accompanying tables; the other two are described in the text. In the 14 tabulated experiments, pigs, dogs, cats, chickens, albino rats, and mice, herein designated as "source animals," were fed one or more times flesh of swine infected with *Sarcocystis*. The animals so fed were autopsied 2 to 7 months later to ascertain whether muscle infections of *Sarcocystis* had been acquired (Table 1). In order to ascertain whether the animals so fed were capable of transmitting the parasite through the feces and urine, and how soon after consumption of infected flesh such transmission could occur, the feces and urine of the source animals were collected at various succesive intervals and fed to pigs that had not been fed meat at any time; the latter pigs are herein designated as "test animals." Methods of housing the experimental animals, feeding the infected meat, feces, and urine, the technique of autopsy, and other pertinent information are briefly summarized.

Maintenance of experimental animals.—Individual test animals and source animals were housed in separate pens or cages which were cleaned daily. In the cleaning process all accumulated feces and urine were first removed; the cage pans pen floors, and the feeding and watering equipment were then cleaned by thorough washing. Even with these precautions it was not always possible to prevent some of the pigs from consuming quantities of their own feces and urine. Rodents and chickens were kept on wire-mesh floors, which aided in preventing coprophagy.

Origin of experimental animals.—Pigs utilized in this investigation were farrowed by sows which are a part of the swine herd of the Zoological Division, and were, after weaning, fed altogether on grain up to the time they were placed on experiment. Natural infections of *Sarcocystis* had never been found in the swine herd of the Zoological Division during a period of approximately 10 years prior to the initiation of these investigations despite the fact that the vast majority of animals autopsied was examined for the presence of these parasites. The rats, mice, dogs, and cats were a part of the small animal colony of the Zoological Division in which *Sarcocystis* had never been found despite repeated searches for it. The chickens used in the experiments had been hatched on the premises of the Animal Husbandry Division and had been maintained on a grain ration up to the time they were used in the experiments.

Origin of the Sarcocystis-infected flesh fed to source animals (Table 1).—In certain of the experiments flesh of naturally infected swine was utilized. In some cases this consisted of infected parts of carcasses detected under federal meat inspection at an abattoir in nearby Virginia and sent to the Zoological Division. In other experiments the flesh of a farm-raised hog found at autopsy to harbor a natural infection of *Sarcocystis* was used. In other cases flesh was taken from the carcasses of hogs infected in previous experiments.

Technique of feeding the Sarcocystis-infected flesh.—The meat was ground in a food chopper before feeding. In certain of the experiments the quantity of infected flesh available was limited and the source animals were, therefore, fed only once. In other experiments larger quantities of infected flesh were available and the source animals were fed for a period of several days (Table 1). In such cases

[2] The investigation was carried out from 1942 to 1944 at the laboratory of the Zoological Division, Bureau of Animal Industry, Department of Agriculture Research Center, Agricultural Research Administration, Beltsville, Md.

TABLE 1.—*Summary of experiments on transmission of Sarcocystis of swine by feeding flesh of infected pigs*[a]

Experiment number[b]	Designation of animals	Approximate age or stage of development	Sarcocystis-infected flesh fed		Autopsy findings		Remarks
			Origin	Feeding period	Date	Miescher's sacs in diaphragm pillars[d]	
		months				*number per gram*	
			Animals known to have consumed their own feces and urine while on experiment				
1	Pig 1119	9	Naturally infected pig	8/ 5/42[c]	10/20/43	3	Good condition when killed
2	Pig 1266	5	do	12/ 1/42 to 12/ 3/42	4/26/43	2	do
3	Pigs 1298						
	1301	2	Naturally infected pig	4/27/43[c e]	11/11/43	14	do
4	Pig 1342	4	Pig 1241	10/ 4/43 to 10/ 9/43	2/25/44	68	Unthrifty; stiff when killed
			Animals not known to have consumed their own feces and urine while on experiment				
5	Pig 1263	5	Pig 1255	12/ 1/42 to 12/ 4/42	4/ 5/43	Not found	Good condition when killed
6	Pig 1176	5	Naturally infected pig	8/20/42[c]	3/30/43	do	do
7	Rats 1 to 6	Half grown	Pig 1266	4/27/43 to 5/ 4/43	11/ 5/43	do	do
8	Mice 1 to 5	Adult	Pig 1261	10/20/43 to 10/23/43	12/28/43	do	do
9	Mice 6 to 10	do	Pig 1241	10/ 1/43 to 10/ 5/43	1/ 5/44	do	do
10	Cats 1 and 2	Half grown	Pig 1266	4/27/43 to 5/ 4/43	11/ 5/43	do	do
11	Dog 1	do	Pig 1266	do	do	do	do
12	Hens 1 and 2	Adult	Pig 1266	4/27/43 to 5/27/43	do	do	do
13	Chicks 1 to 25	1	Pig 1266	4/27/43 to 5/ 1/43	11/ 6/43	do	do
14	Pigs 1171	5	Naturally infected pig	8/22/42[c e]	11/22/42	do	Moribund when killed
	1212	3	do	do[c e]	do	do	Unthrifty when killed
	1213	3	do	do[c e]	do	do	do
	1218	11	do	do[c e]	do	do	do

[a] Animals listed in this table are designed as "source animals" and served as sources of feces and urine for feeding to animals listed in table 2.
[b] Experiments numbered arbitrarily.
[c] Given one feeding of Sarcocystis-infected flesh; others fed twice daily during periods indicated.
[d] Infections found consisted of Miescher's sacs in various stages of development.
[e] Became violently ill after consumption of infected meat.

pigs were fed approximately 200 grams of the flesh morning and night; other animals were fed twice daily as much as they would consume. In the case of pigs and chickens the meat ration was supplemented with grain; in the case of rats, mice, dogs, and cats, no other feed was administered during the period that the infected meat was being fed.

Technique of feeding to test pigs (Table 2) feces and urine of the source animals (Table 1).—With the exception noted in table 2, a period of 3 or more days was allowed to elapse after meat was fed to a source animal before its feces and urine were collected for feeding to test pigs. In all cases the accumulated material was collected twice daily and mixed in approximately 8 to 10 volumes of a moistened grain ration. When large amounts of feces and urine were available, as much was fed as the test pigs would consume; no other feed was administered during the time feces and urine mixed with grain were being fed. With the exceptions noted in table 2, two and sometimes three test pigs were fed at successive intervals the feces and urine of the corresponding source animal or animals. Specifically, one test pig was fed twice daily the feces and urine eliminated by its source animals during a continuous period that began 3 days after meat was last consumed and ended 12 to 19 days after meat was first consumed; these test animals are herein designated as belonging to series 1 (Table 2). As soon as the test pigs of series 1 received their last feeding of feces and urine they were supplanted by test pigs comprising series 2, which were then fed feces and urine of their corresponding source animals during continuous periods ending from 31 to 121 days after the source animals first consumed infected meat. In experiment 3 (Table 2) a third test pig (Series 3) was placed on experiment 61 days after the source animal consumed infected meat and was fed the feces and urine during a period of 24 additional days. In experiment 10 the series 2 test pig died and was supplanted by another pig (Series 3); in this case the last feeding of feces and urine was made on the 69th day after the source animal first consumed infected flesh.

Technique of autopsy.—Animals that died were autopsied within a few hours; the others were killed for autopsy from 2 to 11 months after the first feeding of meat, or feces and urine. At autopsy the various organs and tissues were examined for gross pathology that might possibly be attributed to the infection. Three representative 1-gram samples of muscle tissue taken from the pillars of the diaphragm were minced by means of fine scissors, pressed out very thin in compressoria, and the number of Miescher's sacs counted with the aid of a dissecting microscope. The average of the numbers of sacs found in the 3 samples was considered an index of the degree of infection. If sacs were not found in the first 3 samples, 10 grams of another representative sample from the pillars of the diaphragm were examined. If sacs were not found in the larger sample similar quantities of tissue from one of the shoulders, the abdominal muscles, and the cheek muscles, and all the esophageal musculature were examined. If Miescher's sacs were not found in any of these tissues the animal was considered to be uninfected. In no case were sacs found in abdominal, shoulder, cheek and esophageal muscles when they were not found in the pillars of the diaphragm.

EXPERIMENTAL FINDINGS

The following brief presentation of the findings will serve to point out some of the more outstanding facts elicited in the investigation.

1. Results of Feeding Sarcocystis-infected Flesh

Animals known to have consumed their own feces while on experiment.—Source animals (pigs) of experiments 1 to 4, inclusive, were frequently observed consuming their own feces during the time they were under test. Owing to the construc-

TABLE 2.—*Summary of experiments on transmission of Sarcocystis to test pigs by feeding feces and urine eliminated by animals during various periods after consuming infected flesh*[a]

Experiment number[b]	Pig number	Test pig series number	Approximate age	Feces and urine		Autopsy findings		Remarks
				Origin	Feeding period[c]	Date	Miescher's sacs in diaphragm pillars[d]	
			months				*number per gram*	
1[h]								
2	1267	1	5	Pig 1266	12/ 8/42 to 12/14/42	4/13/43	Not found	Good condition when killed
	1268	2	5	do	12/14/42 to 3/31/43	5/13/43	2	do
3	1262	1	8	Pigs 1289/1301	5/ 6/43 to 5/11/43	10/ 2/43	Not found	do
	1254	2	8	do	5/11/43 to 6/27/43	12/ 2/44	125	Moribund when killed
	1278	3	5	do	7/ 7/43 to 7/21/43	1/ 8/44	7	Good condition when killed
4	1314	1	6	Pig 1342	10/12/43 to 10/23/43	11/25/44	7	do
	1282	2	10	do	10/23/43 to 12/23/43	4/18/44	14	do
5	1264	1	5	Pig 1263	12/ 8/42 to 12/11/42	3/19/43	Not found	do
	1265	2	5	do	12/11/42 to 3/26/43	7/20/43	12	do
6	1255	1	6	Pig 1176	9/ 2/42 to 9/ 8/42	11/30/42	1	Unthrifty when killed
	1189	2	6	do	9/ 8/42 to 10/30/42	3/22/43	6	Good condition when killed
7	1241	1	9	Rats 1 to 6	5/ 8/43 to 5/12/43	10/ 1/43	50	do
	1261	2	8	do	5/12/43 to 7/ 3/43	10/20/43	48	Emaciated; weak when killed
8	1351	1	4	Mice 1 to 5	10/26/43 to 11/29/43	6/22/44[f]	52	do
9	1343	1	4	Mice 6 to 10	10/ 8/43 to 10/15/43	3/9 /44	Not found	Good condition when killed
	1344	2	5	do	10/15/43 to 11/ 8/43	11/ 8/43[e]	Not found	do
10	1246	1	9	Cat 1	5/ 7/43 to 5/16/43	9/25/43	do	do
	1259	2	8	do	5/16/43 to 5/28/43	5/28/43[e]	do	do
	1240	3	9	do	5/29/43 to 7/ 5/43	11/ 7/43	35	Unthrifty when killed
11	1247	1	9	Dog 1	5/ 7/43 to 5/12/43	9/24/43	39	Good condition when killed
	1245	2	9	do	5/12/43 to 7/12/43	12/ 6/43	24	do
12	1244	1	8	Hens 1 and 2	4/27/43 to 5/27/43	11/ 4/43[f g]	23	do
13	1243	1	9	Chicks 1 to 25	4/27/43 to 5/11/43	11/ 5/43	0	do
	1258	2	8	do	5/12/43 to 7/12/43	do	28	Good condition when killed
14[h]								

[a] Animals in this table are designated as "test animals."
[b] Experiment numbers correspond to those in table 1.
[c] Feces and urine fed twice daily during the periods indicated.
[d] Infections unless otherwise indicated consisted of Miescher's sacs in various stages of development.
[e] These animals died; the others were killed for necropsy.
[f] One test animal utilized and fed feces and urine only during the time meat was being fed to source animals.
[g] Feedings of feces and urine to this test animal were initiated the first day infected meat was fed to the source animals (Hens, table 1).
[h] No test animals employed in these experiments.

tion of the pens in which the animals were housed the feces were probably contaminated with urine. At autopsy, all the pigs in question harbored *Sarcocystis* in the musculature; the estimated number per gram of pillars of the diaphragm varied from 2 to 68 (Table 1). The infections were not detectable macroscopically. The kidneys of all the animals in question were enlarged and pale; no abnormalities were observed in the other organs.

Animals not known to have consumed their own feces and urine while on experiment.—Coprophagy was not observed in the pigs utilized as source animals in experiments 5, 6, and 14, and none was found infected at necropsy. In experiments 7 to 13, inclusive, various animals other than pigs were fed meat. Coprophagy was not observed in these animals and none was found infected at autopsy. Kidneys of the pigs, dogs, cats, rats, and mice utilized as source animals in the experiments named were consistently larger than normal, and often pale. Abnormalities were not observed in other organs.

2. Results of Feeding to Test Pigs Feces and Urine of Animals That Consumed Sarcocystis-infected Flesh

Examination of the data presented in table 2 shows the following facts: (1) Muscle infections of *Sarcocystis* were *not* found in the test pigs that consumed feces and urine of their corresponding source animals during periods extending up to 15 days after meat was first consumed. (2) Muscle infections of *Sarcocystis* were found in pigs that consumed feces and urine eliminated by the corresponding source animals during periods beginning 15 or more days after consumption of infected flesh. (3) The numbers of Miescher's sacs observed in samples of muscle tissue taken from the pillars of the diaphragm of each of the various animals were estimated to range from 1 to 125 per gram and were not detectable macroscopically. (4) With the exception of pig 1254 (Experiment 3) the heaviest infections were found in those test animals that consumed feces and urine of source animals other than pigs. (5) In general, pigs harboring infections heavier than approximately 40 sacs per gram of muscle tissue of the pillars of the diaphragm were unthrifty and weak at the time they were killed for autopsy; pig 1254 harboring an infection of 125 sacs per gram was moribund at the time it was killed.

At autopsy no abnormalities were observed in the kidneys, spleen, liver, lungs, and alimentary tract of the test pigs not found infected. In the case of animals found to be infected, however, the kidneys were noticeably enlarged and somewhat pale. In the stomach of each animal there was observed an area of hyperaemia located on the mucosa of the greater curvature of that organ. In some cases the intestines were also hyperaemic. No consistent abnormalities were observed in livers and spleens.

3. Clinical Observations of Experimental Animals

In the investigation herein reported certain definite abnormal conditions were observed in swine fed infected flesh and in the swine fed feces and urine of animals that had consumed infected flesh. Consumption of large numbers of sarcocysts by pigs was in some cases followed by transient but none the less violent reactions indicative of a toxemia. For example, in experiment 3, pigs 1289 and 1301 (Table 1) were each fed 200 grams of muscle tissue containing an estimated 1,200 Miescher's sacs. Six hours later a condition suggestive of severe toxemia was observed in both pigs, the condition being characterized by vomiting, staggering gait, and deep labored breathing, but with little or no elevation of the rectal temperatures. The next day the pigs refused feed, there was marked inspiratory dyspnoea, and the animals lay with the fore part of the body supported off the

floor. The condition persisted for approximately 5 days during which time very little feed and water were consumed. Within the next week or two, the appetites improved and the animals became active, but were weak in the region of the loins. The growth rate was markedly retarded during the period of about 2 months after recovery.

Symptoms of severe toxemia were also observed in the 4 pigs involved in experiment 14 (Table 1), which were each fed an undetermined number of sarcocysts contained in approximately 50 grams of muscle tissue from a naturally infected hog. Within 1 hour after meat was consumed vomiting occurred, breathing was rapid and labored, and the gait was staggering. Approximately 2 hours later the condition had subsided somewhat and each pig consumed the major portion of the vomitus; this was followed in approximately 1 hour by vomiting and difficult breathing. The next day the symptoms of toxemia had subsided but from that time until autopsy the pigs suffered from anorexia and frequent diarrhea, the feces being bile-stained and of a foul odor. Loss of weight occurred and spells of transient posterior paralysis developed from time to time. Approximately 3 months after meat had been consumed, one of the animals became moribund and, together with others, it was killed for autopsy. As stated previously, no sarcocysts were found in the musculature.

Less marked reactions were observed in the remainder of the source pigs, these animals having been fed smaller numbers of sarcocysts than were administered to pigs in experiments 3 and 14. The former animals, however, all became inappetent for periods of a few days and later exhibited weakness of the loins, culminating in sort periods of posteriar paralysis.

In the case of animals other than pigs, no very marked reactions to consumption of infected flesh were observed. The dogs and cats exhibited a distaste for the meat after 2 or 3 feedings and suffered with a diarrhea lasting 1 or 2 days. Failure to eat the meat and the accompanying diarrhea were at that time considered to be of little moment because dogs and cats often do not tolerate well a diet of raw pork. In the case of rats and mice, diarrhea generally occurred, the severity apparently being associated with the number of parasites administered. These animals generally appeared depressed and weak for several days but recovered from these symptoms. Diarrhea was not observed in chickens fed infected flesh.

In the case of pigs fed feces and urine of animals that had consumed infected flesh, there generally occurred one or more periods of posterior paralysis and generalized stiffness of the muscles, together with unthriftiness which was either temporary or progressive. As stated previously, only those animals found at autopsy to harbor infections heavier than 40 sarcocysts per gram of diaphragm muscle tissue showed any permanent effects of the parasitism; such animals were generally weak and unthrifty at the time they were killed for autopsy. The most notable example was pig 1254 (Experiment 3), which was moribund when killed. During approximately 1 month prior to autopsy, this animal lost weight and from time to time was too weak to rise; the individual spells of extreme weakness persisted about 2 or 3 days after which the animal was able to stand alone and move about at will for several days. The movements were, however, stilted and the animal was stiff, and weak in the region of the loins. Three days before autopsy this hog became unable to rise and soon became moribund.

In the case of swine harboring lighter infections there usually occurred a period of weakness in the loins, which in some cases culminated in paralysis of the hind quarters. The paralysis usually lasted from 1 to approximately 5 days and recovery was rapid and apparently complete.

In experiments 9 and 10 (Table 2) death of the series 2 test pigs occurred 25 and 12 days, respectively, after feeding of urine and feces were initiated. In

each case the only symptom noted was a sudden onset of inappetence followed by death within 24 hours. Microscopic examination of teased out muscle fibers revealed the presence of groups of minute refringent granules, some of which were in the process of division. It is believed that these accumulations of granules represented early stages of an infection of *Sarcocystis*.

None of the conditions enumerated were observed in swine fed feces and urine of animals not known to have consumed infected flesh, or in those fed feces and urine eliminated by animals prior to 15 days after consuming infected flesh. The latter test pigs did not become infected.

4. Results of Feeding to Pigs Feces and Urine of Animals Not Known to Have Consumed Sarcocystis-infected Flesh

Two experiments were carried out to ascertain whether pigs would acquire an infection of *Sarcocystis* from consuming feces and urine of animals not known to have consumed infected flesh; each experiment is briefly summarized below.

In one experiment, feces of wild rats and feces and urine of albino rats and mice were fed twice daily in a wet grain mash to 3 pigs 4 to 6 months old; as much of the mixture was fed as the pigs would consume. Feedings were continued for a period of 2 months; during that time the pigs remained thrifty and grew rapidly. Four months after the last experimental feeding extensive examinations were made of muscles from the pillars of the diaphragm, the abdomen, the shoulder, the cheeks, and the esophagus of each animal; Miescher's sacs were not found.

In another experiment 3 pigs 4 months old were fed twice daily, during a period of 2 months, large amounts of composite collections of feces and urine passed by various swine not known to have consumed flesh of any kind; no ill effects from consumption of the feces and urine were observed. Six months after the last experimental feeding these animals were killed for autopsy. *Sarcocystis* was not found in extensive examinations of muscles from various parts of the body. No abnormalities were observed in the alimentary tract, or in the various organs of the animals involved in the 2 experiments just described.

CONTROL ANIMALS

From 1 to 3 control pigs were utilized in each experiment; these animals are not listed in the tables. Pigs utilized as controls were, in most cases, litter mates of the corresponding pigs used in the transmission experiments. At autopsy the controls ranged in age from 8 to 18 months. None was found to be infected. In addition, as shown in tables 1 and 2, 13 of the pigs involved in the experiments herein reported were found at autopsy to be free of infection with *Sarcocystis*. In addition, there were, during the time the investigation was in progress, 22 other pigs of various ages involved in other experiments and kept in pens in more or less close proximity to those involved in the investigation herein reported; none of these pigs was found infected at autopsy. Moreover, 6 adult sows, which had been maintained on the premises of the Zoological Division for 7 years, were autopsied during the time this investigation was in progress and none was found to be infected. Over a period of several years prior to the time this investigation was initiated, approximately 900 pigs of various ages had been utilized in various experiments and autopsied; none was found to be infected. Also, subsequent to this investigation, 27 pigs of various ages utilized in controlled experiments with other parasites have been autopsied; none was found to be infected with *Sarcocystis*. In view of these facts it is believed that the infections reported in this paper were experimentally induced.

DISCUSSION

For years the mode of infection of pigs and other animals with *Sarcocystis* had not been definitely understood, and the views on this problem as expressed in the literature were rather contradictory. In the investigation herein reported it was ascertained that swine, dogs, cats, rats, mice, and chickens are, after consuming flesh of infected swine, capable of transmitting *Sarcocystis* through elimination with their feces and/or urine a stage that is infective to swine, the latter becoming infected by consuming such feces or urine. These findings are in harmony with those of Négre as regards the transmission of *Sarcocystis* to mice. The findings herein reported in conjunction with those of Négre serve to explain the frequent occurrence of *Sarcocystis* in garbage-fed hogs (Alicata, 1932) since animals so fed undoubtedly consume from time to time scraps of infected pork contained in the garbage. Since the food of such animals is generally liberally contaminated with their own urine and feces, the high incidence of *Sarcocystis* in swine can be readily understood in the light of the data presented in this paper. Furthermore, the premises of garbage-feeding establishments are usually infested with rodents which, after consuming infected flesh, would presumably be capable of disseminating the infection to swine through their feces and urine. On farms, the feeding of scraps of infected pork to pigs, and to dogs, cats, and chickens, which frequent feed lots and pastures, may account for the presence of *Sarcocystis* in swine raised under these conditions.

The facts presented in this paper throw light on the sources of *Sarcocystis* infections which are known to be common in range-fed cattle and sheep. There is at this time little reason to suppose that the mode of dissemination of *Sarcocystis* infecting these animals is any different from that of the species infecting swine. Consequently, it may be assumed that dogs, predatory mammals, scavenger birds, and rodents serve to disseminate the parasite through the elimination of infective stages with the feces and urine deposited on grass and in water holes.

In the investigation herein reported, transmission of the parasite through feces and urine of animals that consumed infected flesh did not occur until a period of 15 or more days elapsed after meat had been consumed. This supports the findings of Négre (1907), who was able to transmit *Sarcocystis* to mice by feeding feces eliminated by other mice subsequent to 15 days after consuming meat, but not before that time. The findings of Négre and those reported in this paper help to explain the apparent transmission of the parasite by Smith (1901), Darling (1910), and others by feeding infected flesh. Inasmuch as these investigators apparently exercised few, if any, precautions to prevent coprophagy by the experimental animals they used, it seems reasonable to conclude that the muscle infections produced were probably a result of consumption by the animals of their own feces, which were probably contaminated with urine.

Négre (1918) reported that suckling mice whose dams had previously been fed Sarcocystis-infected flesh harbored at autopsy muscle infections of this parasite. A somewhat similar observation was made during the course of the investigation herein reported. In experiment 13, the series 2 test animal, a young sow, (No. 1258), shown in table 2, farrowed 3 pigs 78 days after being placed on experiment and 18 days after the last feeding of feces and urine. Two of the pigs were killed by overlaying. The remaining pig was autopsied when 98 days old and found to harbor an infection of 11 Miescher's sacs per gram of diaphragm tissue. Inasmuch as the feedings of urine and feces to the sow had been discontined before the pig in question was born, it is assumed that the infection had been prenatally acquired.

With one exception (Pig 1254, Experiment 3), the heaviest infections found in these experiments were in pigs fed feces and urine of source animals other than

swine. In experiment 3 and in experiments involving source animals other than swine, the animals were maintained on wire mesh floors with pans beneath for collecting urine and feces. In such cases the accumulated urine was mixed with the feces for feeding to test animals. The heavier infections in the test pigs so fed, together with the occurrence of loin weakness and enlargement of the kidneys observed in animals that consumed meat, suggest the possibility of invasion by the parasite of the kidneys of animals consuming flesh harboring *Sarcocystis*.

SUMMARY

An investigation to ascertain the mode of transmission of *Sarcocystis* to swine and the clinical pathologic effects of the parasites on the host animals revealed the following facts:

1. Pigs, dogs, cats, rats, mice, and chickens, are, after consuming flesh of infected swine, capable of transmitting *Sarcocystis* through elimination, with their feces and/or urine, a stage that is infective to swine, the latter becoming infected by consuming such feces or urine. In these experiments, transmission was not accomplished by feeding feces and urine eliminated by animals prior to 15 days after infected flesh had been consumed. Infection was accomplished by feeding feces and urine eliminated subsequent to 15 days after infected flesh was consumed.

2. Pigs fed infected flesh did not acquire *Sarcocystis* unless they consumed their own feces and urine.

3. Symptoms observed in pigs following ingestion by these animals of heavily infected flesh included vomiting, diarrhea, inappetence, weakness of the loins, and temporary posterior paralysis.

4. Symptoms observed in pigs fed feces and urine eliminated by animals subsequent to consumption of infected flesh included unthriftiness, weakness of the loins, and temporary posterior paralysis, sometimes recurring at intervals. Pigs found at autopsy to harbor the heaviest infections were the most severely affected. In general, infections of 40 or more sarcocysts per gram of diaphragm tissue were associated with unthriftiness, and stiffness of the muscles.

5. The heaviest infections were found in those animals that consumed the greatest amounts of urine along with the feces.

6. Lesions found at autopsy of the infected animals were enlargement and paleness of the kidneys and hyperaemia of the mucosa of the stomach and intestines.

7. Pigs fed feces and urine of pigs, rats, and mice that had not consumed meat did not become infected with *Sarcocystis* and showed none of the symptoms and lesions observed in infected animals.

LIST OF REFERENCES

ALICATA, J. E. 1932. The incidence of protozoa in domestic swine. (Abst. of Rept. Helminth. Soc. Wash., Dec. 1931.) Jour. Parasitol. 18(4): 310.

BEHLA, ROBERT. 1897. Ueber die systematische Stellung der Parasiten der Miescher's schen Schläuche und deren Züchtung. (Vorläufige Mitteilung) Berlin Tierärztl. Wchnschr. (47), Nov. 25: 564–566.

BERGMAN, ARVID MATHIAS. 1913. Beitrag zur Kenntnis des Vorkommens der Sarkosporidien bei den Haustieren. Ztschr. f. Fleisch u. Milchhyg. 23(8): 169–180.

CREECH, G. T. 1922. Sarcosporidiosis of swine, associated with advanced degenerative changes in the musculature. Jour. Amer. Vet. Med. Assoc., 61, n.s. 14(4): 383–392.

DARLING, SAMUEL T. 1910. Experimental sarcosporidiosis in the guinea pig and its relation to a case of sarcosporidiosis in man. Jour. Exper. Med. 12(1): 19–28.

GALLI-VALERIO, BRUNO. 1913. Notes de parasitologie et de technique parasitologique et observations sur quelques tumeurs des animaux. Centbl. Bakt. Abt. Orig. 69(7): 496–504.

MINCHIN, E. A. 1903. The Sporozoa. A treatise on zoology, Ed. by E. R. Lankester, Part I, second fasciola, pp. 150–360.
NÉGRE, L. 1907. Sarcosporidiose experimentale. Soc. de Biol. [Paris] 63(30): 374–375.
———. 1910. Sur le stade intestinal de la sarcosporidie de la souris. Soc. de Biol. [Paris] 68(21): 997–998.
———. 1918. Recherches experimentales sur l'evolution de la sarcosporidie de la souris. Bull. de l' Institut Pasteur 16(30): 507–508.
OSTERTAG, ROBERT. 1904. Handbook of meat inspection (Transl. Earley Vernon Wilcox). William R. Jenkins, New York.
SCOTT, JOHN W. 1915. Some notes and experiments on *Sarcocystis tenella*, Railliet. Jour. Parasitol. 2(1): 20–24.
———. 1943. Life history of Sarcosporidia, with particular reference to *Sarcocystis tenella*. Univ. of Wyoming Agr. Expt. Sta. Bull. 259, pp. 1–63.
SMITH, THEOBALD. 1901. The production of sarcosporidiosis in the mouse by feeding infected muscular tissue. Jour. Expt. Med. 6(1): 1–21.

The probable origin of some unusually heavy infections with the common sheep hookworm *(Bunostomum trigonocephólum)*. R. T. HABERMANN, U. S. Bureau of Animal Industry.

So far as is indicated by reports known to the writer, the number of hookworms harbored by an infected sheep usually is surprisingly small. In Scotland, Cameron (1923, Jour. Helminth. 1(2): 53–60) found an average of 10.5 hookworms in 38 infected sheep; the largest number in one sheep was 31. In examinations of sheep slaughtered in Ontario, Fallis (1938, Trans. Roy. Canad. Inst., 22, Pt. 1 (47): 81–128) found 16 hookworms per infected sheep; the maximum number in one sheep was 154. Curtice (1890, The animal parasites of sheep. 222 pp., U. S. Dept. of Agr. [Washington]) stated that usually fewer than 100 are found and not more than 200 to 300 ever seem to be present. Threlkeld (1941, Va. Agr. Expt. Sta. Tech. Bull. 68, pp. 3–46) reported 40 to 50 per infected sheep examined in Virginia. However, in one yearling he found 494. No heavier infection than this one has been reported, to the writer's knowledge.

Eighty-nine sheep infected with *Bunostomum* have been examined at necropsy by the writer during the past 6 years at the Beltsville, Md., Research Center. Some of the animals had been therapeutically or prophylactically treated in anthelmintic experiments and some were untreated controls in prophylactic experiments. If an animal had received a therapeutic dose of a drug, the size of its infection was determined by adding the number of hookworms eliminated to the number found at necropsy. Thirty-four of these sheep had been purchased in 1938 and 1939 at Baltimore, Md., and were kept at the Beltsville station for only a short time before necropsy; the average infection in this group was 50.1 hookworms. The remaining 55 sheep were born and reared at the Beltsville Research Center; the average infection among them was 86.8 hookworms.

In the latter group, three infections heavier than the one reported by Threlkeld were encountered. In a mature ram, number 89, which was treated therapeutically and necropsied in November, 1942, the infection totalled 555 hookworms; a 5-year-old ram, number 280, examined in January, 1944, following an interval in which small doses of an anthelmintic were available to it, yielded 634 hookworms, and in ram number 399, a control of like age examined in December, 1943, were found 982 hookworms.

The history of one of these rams is not known in detail, but the available information concerning two of them is sufficient to be suggestive of the nature of the conditions that favored acquisition of their unusual infections.

It should be noted, before these conditions are described, that the usual mode of entry of *B. trigonocephalum* larvae into the host is not known with certainty. In 1937, Ortlepp (Onderstepoort Jour. Vet. Sci. and Anim. Indus. 8(1): 183–212)

referred to the view that infection with this species takes place only by the oral route as "generally held." However, Beller (1926, Ztschr. f. Infektionskrank. **29**(3): 173–183), who investigated an outbreak of disease diagnosed as bunostomiasis, previously had concluded that his observations pointed to infection through the skin. He regarded bunostomiasis, in distinction to parasitic diseases acquired on pastures, as a disease of winter-stabled sheep. In 1928, (Ztschr. f. Infektionskrank. **32**(3): 232–251) he reported that infection can occur by either the oral or percutaneous route and, in 1939, Ortlepp (Onderstepoort Jour. Vet. Sci. and Anim. Indus. **12**(2): 305–318) clearly confirmed experimentally the occurrence of infection by both routes. However, the experiments of these authors did not indicate which mode of entry is the more efficient. Lucker and Neumayer (1944, Jour. Parasitol. **30**(Suppl.): 10) recently stated that one experimental lamb given hookworm larvae orally failed to become infected while a second did not become appreciably infected. They obtained heavy percutaneous infections in 2 of 4 lambs. All details of dosages employed were not given in their abstract, but it is very probable that they found the percutaneous route to be the more efficient. The closely related sheep hookworm, *Gaigeria pachyscelis*, infects exclusively by skin, so far as is known.

Available records indicate that rams 280 and 399 were kept in a small bare lot or feeding pen with several other sheep for about 6 months previous to May, 1943. The sheep so confined were fed hay and provided bedding with the result that a deep litter of coarse stems and of straw accumulated in a part of the enclosure. Subsequently, until the time of necropsy, each ram was kept with other sheep in a small overstocked pasture lot. Supplementary feeding was again necessary and in a short time an accumulation of uneaten hay and excreta built up in each of the lots.

Not only may this litter have provided an unusually favorable site for the development and survival of infective larvae, but since it is generally conceded that skin-penetrating larvae enter sheep mainly through the interdigital skin and the skin of the lower legs and of the muzzle, it is evident that the rams, while standing for long periods in this deep litter to eat their hay, had unusual opportunity to become infected by such larvae. The findings do not preclude, of course, the possibility that the infections may have been acquired in consequence of the ingestion of larvae.

It appears to the writer that the conditions mentioned were responsible for two of the unusually heavy hookworm infections here reported. Also of interest, because worm infections are, as a rule, heaviest in young sheep, is the advanced age of the three heavily infected rams. However, under similar conditions and exposure, younger animals would presumably have acquired even larger numbers of hookworms than those encountered in these rams.

A preliminary study of the occurrence of internal parasites of animals in Mississippi.[1] J. W. Ward, Mississippi Experiment Station, State College, Mississippi.

During the past twelve years, the writer has autopsied a number of animals in Mississippi and examined them for the presence of internal parasites. The presence of internal parasites has also been determined through fecal examinations of a number of animals. So far as the writer can ascertain from the literature, a number of the parasites encountered in this survey have not been reported as occuring in Mississippi. The results of this survey are based upon findings at autopsy of 349 animals, comprising 5 horses and mules; 8 cattle; 6 sheep; 1 deer; 10 rats; 10

[1] A contribution from the Department of Animal Diseases, Mississippi Experiment Station, published with the approval of the Director as paper No. 103, new series.

chickens; 283 quail; 20 dogs; 6 rabbits and findings from fecal examinations of 301 animals, comprising 133 cattle; 52 horses and mules; 93 sheep; 6 hogs; 7 chickens and 10 dogs. The accompanying list shows the parasites recorded from animals in Mississippi.

It is interesting to note the early age at which mule colts become infested with certain nematode parasites. Fecal examinations of two 5-day old colts showed them to be negative for nematode parasites. At the age of 26 days, fecal examinations of these colts showed them to be mildly infested with *Strongyloides sp.* and *Strongylus spp.* Fecal examinations of a 15-day old colt showed the animal to be mildly infested with *Strongylus spp.*, (*S. edentatus* or *S. vulgaris*), *Parascaris equorum* and *Strongyloides sp.*

HORSE AND MULE

Gastrophilus nasalis, G. intestinalis, Parascaris equorum, Strongylus equinus, S. vulgaris, S. edentatus, Triodontophorus minor, T. serratus, Cylicocercus gold, Cylicocyclus elongatus, C. nassatus, Oxyurus equi, Dictyocaulus arnfieldi, Setaria equina, Strongyloides sp., Anoplocephala sp.

CATTLE

Moniezia expansa, Fasciola hepatica,[2] *Dictyocaulus viviparus, Nematodirus sp., Ostertagia marshalli, Haemonchus contortus, Bunostomum phlebotomum, Cooperia punctata, Neoascaris vitulorum, Strongyloides sp., Trichuris ovis, Setaria labiato-papillosa, Oesophagostomum radiatum, O. columbianum, Eimeria sp., E. zurnii, E. cylindrica, E. bovis, E. canadensis.*

SHEEP

Moniezia expansa, Cysticercus tenuicollis, Strongyloides papillosus, Haemonchus contortus, Bunostomum phlebotomum, Ostertagia ostertagi, Nematodirus sp., Trichuris ovis, Oesophagostomum radiatum, O. columbianum, Eimeria sp., E. bovis, E. zurnii, E. cylindrica.

HOG

Ascaris lumbricoides, Oesophagostomum dentatum, Trichuris suis, Choerostrongylus pudendotectus, Stephanurus dentatus, Balantidium coli, Macracanthorhynchus hirudinaceus, Taenia solium.

CHICKEN

Raillietina tetragona, Hymenolepis carioca, Gongylonema sp., Heterakis gallinae, Ascaridia galli, Eimeria spp., Cytoleichus nudus.

DOG

Dipylidium caninum, D. sexcoronatum, Taenia pisiformis, Dirofilaria immitis, Toxocara canis, Ancylostoma caninum, Trichuris vulpis, Paragonimus westermanii.

RABBIT

Cittotaenia ctenoides, Cysticercus pisiformis, Hasstilesia tricolor, Trichuris leporis, Graphidium strigosum, Passalurus embiguus, Eimeria spp.

RAT

Hymenolepis diminuta, H. nana, Cysticercus fasciolaris, Trichinella spiralis, Heterakis spumosa, Trypanosoma lewisi.

[2] Collected by Dr. J. W. Scales from cattle shipped from Texas.

QUAIL

Heterakis gallinae, Heterakis bonasae, Subulura brumpti, Seurocyrnea colini, Habronema pileata, Syngamus trachea, Trichostrongylus pergracilis, Rhabdometra odiosa, Raillietina (Skrjabinia) cesticillus, Hymenolepis carioca, Eimeria spp.

SUMMARY

This survey shows at least 86 species of internal parasites as being recorded from animals in Mississippi. They may be listed according to host and type of parasite.

Horse and Mule.—Two species of bot fly larvae, 13 of nematodes, and 1 of cestode.

Cattle.—Twelve species of nematodes, 1 of cestode, 1 of trematode, and 5 of *Eimeria.*

Sheep.—Eight species of nematodes, 2 of cestodes, and 4 or more of *Eimeria.*

Hog.—Five species of nematodes, 1 of cestode, 1 of Acanthocephala, and 1 protozoan.

Chicken.—Three species of nematodes, 3 of cestodes, 1 internal mite, and 1 or more *Eimeria.*

Quail.—Seven species of nematodes, 2 of cestodes, and 1 or more of *Eimeria.*

Dog.—Four species of nematodes, 3 of cestodes, and 1 of trematode.

Rabbit.—Three species of nematodes, 2 of cestodes, 1 of trematode, and 1 or more of *Eimeria.*

Rat.—Two species of nematodes, 3 of cestodes, and 1 trypanosome.

A new nematode, *Longistriata caudabullata*, n. sp. (Nematoda: Vianaiinae), from the short-tailed shrew, *Blarina brevicauda*. G. DIKMANS, U. S. Bureau of Animal Industry.

So far as information available to the present writer is concerned, no nematodes have previously been described as parasites of the short-tailed shrew, *Blarina brevicauda.* Recently several specimens of an apparently undescribed species of *Longistriata* were collected from this host and are described as follows:

Longistriata caudabullata, n. sp.

Description.— Longistriata. Males 1.5 to 1.8 mm. and females 1.7 to 2 mm. long. Body rolled in from 4 to 6 loose spirals. Cuticle marked with fine transverse and longitudinal striations, the transverse striations being especially noticeable on the longitudinal striae. Cephalic inflation about 0.05 mm. long and 0.03 mm. wide, without noticeable cross striations.

Male with relatively large caudal bursa, about 0.110 mm. long and 0.160 to 0.180 mm. wide. Ventral rays widely separated from each other and differing markedly in size, the ventro-ventral being much smaller than the venutro-lateral. All the ventral and lateral rays are very sharply pointed and all except the antero- or externo-laterals reach the margin of the bursa. The medio- and postero-laterals have a common stem. The dorsal rays have a comparatively large common stem and the dorsal divides into two rather widely separated branches which end in sharp, undivided points. Spicules simple, thin and slender, about 0.200 mm. long. Gubernaculum boat-shaped, about 0.060 mm. long. Genital cone large, prominent, and provided with a number of papillae. Prebursal papillae present.

Female with posterior end of body thickened and with a large vesicular swelling on the dorsal side of the terminal portion of the body. The body narrows abruptly behind the anus and the tail ends in a well-marked, 0.015 mm. long, bluntly rounded point, which appears to be a prolongation of the body wall sur-

rounded by a prolongation of the slightly inflated cuticle; there are two small processes or papillae, one on each side, near the point of origin of this point or prolongation. Uterus and ovejector single. Anus about 0.04 mm. and vulva about 0.06 mm. from tail end. Eggs thick shelled, 0.050 to 0.060 mm. long and 0.030 mm. wide.

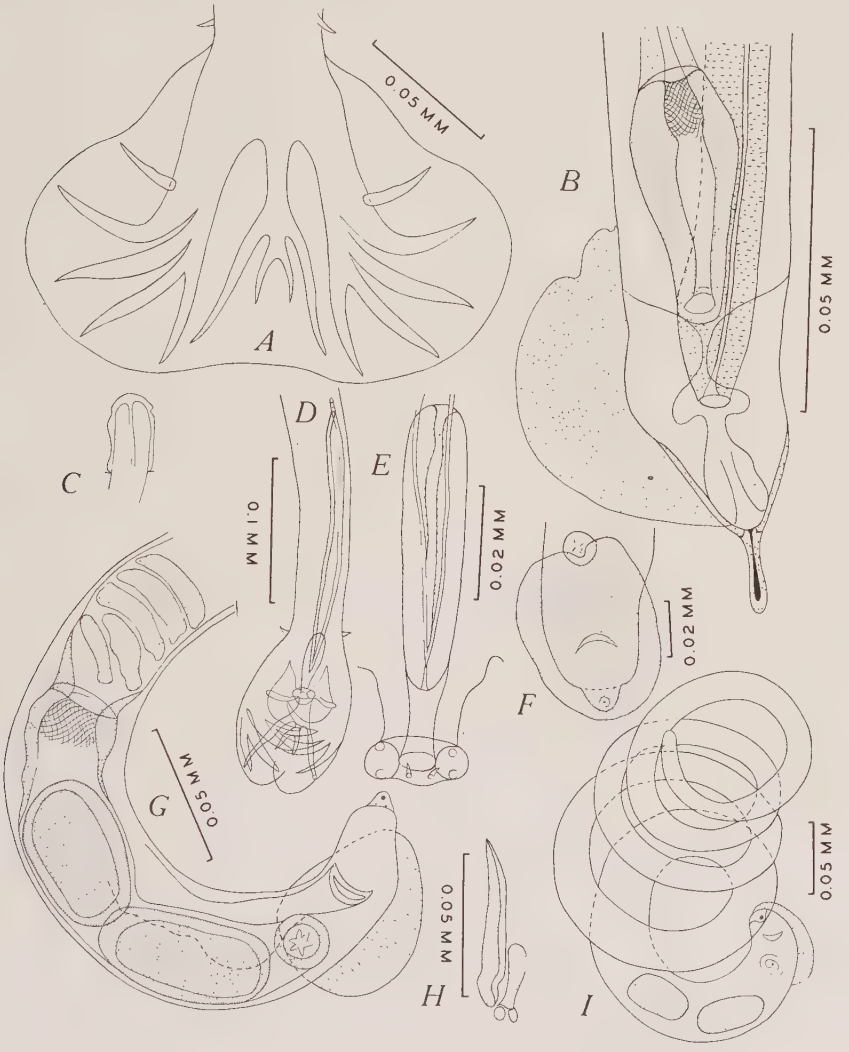

FIG. 1. *Longistriata caudabullata.* A—Bursa. B—Posterior portion of female showing caudal prolongation. C—Head end. D—Posterior end of male showing spicules. E—Gubernaculum and genital cone. F—Tail end of female, dorsal view. G—Posterior portion of female with eggs *in utero.* H—Gubernaculum, lateral view. I—Female.

Host.—*Blarina brevicauda.*

Location.—Small intestine.

Locality.—Hyattsville, Prince George County, Maryland.

Specimens.—U. S. Nat. Mus. Helm. Coll. No. 45122 (types), and 45123 (paratypes).

The most striking feature of this nematode is the large vesicular swelling on

the dorsal side of the terminal portion of the body of the female. Another interesting feature is that, in the females, only two eggs have been noted to be present in the uterus.

This nematode has been placed in the genus *Longistriata* because, in general, it has the characters found in the generic description of that genus, and in spite of the fact that Travassos (Revisão de Familia Trichostrongylidae Leiper, 1912, Monographias do Instituto Oswaldo Cruz, No. 1, Dezembro, 1937) states in his diagnosis of the genus, that the tails of the females are not provided with terminal spines, or as he states, "Cauda conica e aguda, sem espinho terminal." The presence of a caudal prolongation or spine in the female, however, does not prevent its inclusion in this genus because the female of the type species of the genus, namely, *Longistriata depressa* (Dujardin, 1945) Shult's 1926, is described by Dujardin (Historie Naturelle des Helminthes ou Vers Intestinaux. Paris. 1845) as having "une queue epaisse obtuse, un peu recourbée et mucronée ou terminée par une pointe grele longue de 0.032 mm. implantée sur le millieu." Since generic characters are fixed by the type species, nematodes that, on the basis of other characters, can properly be placed in the genus *Longistriata* should not be excluded from that genus because of the presence of a terminal spine on the body of the females.

Dujardin (*loc. cit.*) published no figures illustrating the species he described as *Strongylus depressus,* but von Linstow (Helmintologische Untersuchungen, 1880a) published a figure of the male bursa of a nematode which is identified with Lauer 13 Feb
Strongylus depressus described by Dujardin. Assuming that Dujardin and von Linstow were dealing with the same species and that von Linstow's figure of the bursa is reasonably correct, it is interesting to note that there is a remarkable resemblance between the dorsal ray of the form described by von Linstow as *Strongylus depressus* and which later was made the type species of the genus *Longistriata,* and the dorsal ray of the nematode here described as *Longistriata caudabullata.* In both nematodes the externo-dorsal and dorsal rays have a common stem and also in both forms the branches of the dorsal ray are rather widely separated and end in undivided sharp points. If it were not for the large and prominent vesicular swelling on the dorsal side of the terminal portion of the body in the female of the species described herein as *L. caudabullata,* the writer would be inclined to identify it with *L. depressa* (Dujardin,1845) Shult's 1926. This is such a striking feature that it would not have escaped both Dujardin's and von Linstow's notice if it had been present in the specimens examined and described by them. Incidentally, *L. depressa* and *L. caudabullata* are the only two members of the genus *Longistriata* in which the branches of the dorsal ray are undivided at the tips; both have been collected from members of the family *Soricidae.*

The genus *Aelurostrongylus* Cameron, 1927 (Nematoda: Metastrongylidae), and its relatives; with descriptions of *Parafilaroides,* gen. nov., and *Angiostrongylus gubernaculatus,* sp. nov.[1] Ellsworth C. Dougherty, Department of Zoology, University of California, Berkeley, California.

In a recent paper (Dougherty, 1943) I reviewed in a preliminary manner the metastrongylid genera *Filaroides* v. Beneden, 1858, and *Metathelazia*[2] Skinker,

[1] The advice and criticism of Dr. Frans C. Goble, Winthrop Chemical Company, Rensselaer, New York, is gratefully acknowledged.

[2] In the earlier paper there was listed under this genus the species *Metathelazia felis* (Vogel, 1928) Dougherty, 1943, but its type host was not indicated; this is the ocelot or tiger cat, *Felis pardalis* Linné (?subsp.). As another possible synonym of *M. felis* may be mentioned *Filaria felis-mellivorae* (*pulmonalis*) Molin, 1858 (see Molin, 1858) from the lungs of the eyra or jaguarondi, *Felis jaguarondi* Cuvier (?subsp.).

1931, and indicated that their affinities were with the genus *Aelurostrongylus* and closely related genera, which I believe should be placed with *Filaroides* and *Metathelazia* in a subfamily Filaroidinae Skriabin, 1933, of the family Metastrongylidae Leiper, 1909. At the present time, however, it is not definitely contemplated to bring out later a more detailed study of the forms considered herein, whereas in the case of *Filaroides* and *Metathelazia* such a work is in preparation.

Current classifications of the "superfamily Metastrongyloidea" (= family Metastrongylidae) such as those of Chitwood and Chitwood (1937) and Skriabin (1941) make use of a subfamily Filaroidinae, but place it in the family Pseudaliidae Railliet, 1916, along with the lungworms of porpoises and restrict it to forms in which the bursa of the male is reduced to a vestige or is entirely lacking.

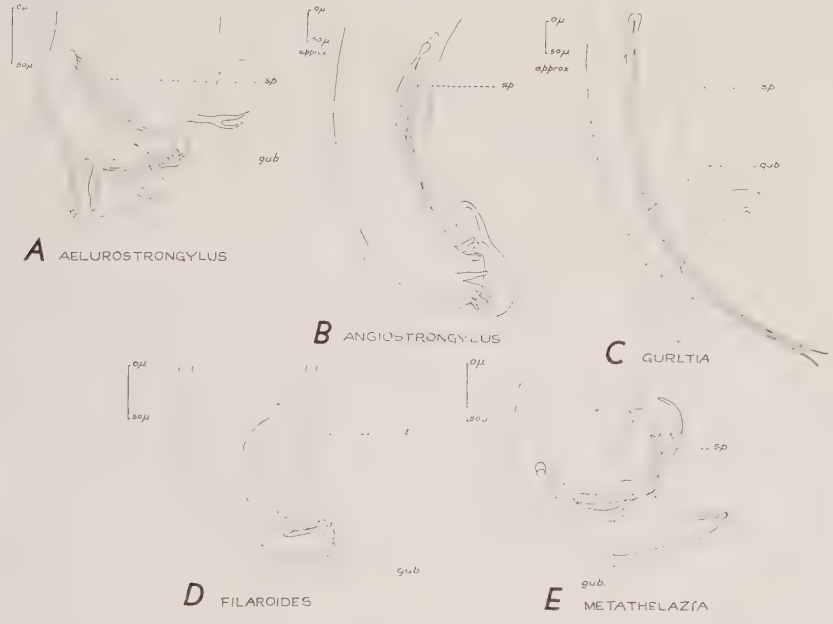

FIG. 1. Lateral views of the male posterior end for the genera of the Filaroidinae (except *Parafilaroides*, gen nov.) showing progressive degeneration of the bursa and rays. A—*Aelurostrongylus fengi* (Hsü, 1935), comb. nov. (after Hsü, 1935, fig. 11). B—*Angiostrongylus raillieti* (Travassos, 1927), comb. nov. (after Travassos, 1927, figure on page 60). The original scale for this figure disagrees with measurements given in the text. C—*Gurltia paralysans* Wolffhügel, 1933 (after Wolffhügel, 1934, fig. 4). D—*Filaroides arator* (Chandler, 1931) Skriabin, 1940 (after Gebauer, 1933, fig. 3). E—*Metathelazia massino* (Davtian, 1933) Dougherty, 1943 (after Davtian, 1933, fig. 1). *sp.*, spicule; *gub.*, gubernaculum.

Chitwood and Chitwood (1937) did not indicate the exact composition of the subfamily as used by them. Skriabin (1940, 1941) has restricted it to the genera *Filaroides* and *Osleroides* Orlov, Davtian, and Liubimov in Skriabin, 1933 (= *Metathelazia*). However, despite the fact that certain of the porpoise "pseudaliids" show in common with these filaroidin genera striking reduction of the bursa and bursal rays from the typical strongyline condition, I believe that bursal reduction in the two groups is the result of separate evolutionary processes whereby forms in two different lines with relatively well-developed bursae have given rise to forms with degenerate bursae. The Filaroidinae belong, with certain other lungworms of terrestrial and aquatic mammals, in the family Metastrongylidae. A

complete classification of this family into subfamilies is left to a later work in which will be offered diagnoses for the metastrongylid supergeneric groups which I believe should be recognized.

The already established genera that I accept in the Filaroidinae are—besides *Filaroides*, *Metathelazia*, and *Aelurostrongylus*—*Angiostrongylus* Kamenskiĭ, 1905, and *Gurltia* Wolffhügel, 1933. All filaroidins occur in the lungs or circulatory system of carnivores, rodents, and primates. The genus *Rodentocaulus* Shul'ts, Orlov, and Kutas, 1933, is in my opinion insufficiently different from *Angiostrongylus* to justify its retention; presumably there are small areas of sclerotization in the bursa which Shul'ts *et al.* (1933) consider homologous to the protostrongylin arcus, but I do not feel that this is sufficient evidence on the basis of which the genus can be recognized. The genus *Cardionema* Yamaguti, 1941 (*nec Cardianema* Alicata, 1933) was based upon female specimens only. Yamaguti (1941) placed the type and only species, *Cardionema ten* Yamaguti, 1941, in the family Filariidae Claus, 1885, but morphologically it is typically metastrongylid. *Cardionema* is here tentatively placed in synonymy with *Angiostrongylus*, where it most likely belongs in view of the habitat of "*C.*" *ten*, namely in the heart of its host, in common with the other species. In addition I am erecting here a new genus, *Parafilaroides*, gen. nov., with genotype *Pseudalius gymnurus* Railliet, 1899, from the lungs of the common harbor seal (*Phoca v. vitulina*). In *Parafilaroides* fall three as yet undescribed species from sea-lions already recorded under *Filaroides* (by Dougherty, 1943).

Figure 1 shows the male posterior ends of one representative species for each of the well-defined genera of the Filaroidinae (except *Parafilaroides*) and illustrates stages of bursal reduction. It suggests the sort of progressive degeneration which the more specialized filaroidins must have undergone.

The six filaroidin genera can be keyed on male characters as follows:

1. Bursa reduced in size but distinct; rays digitiform 2
   Bursa essentially lacking; rays reduced to papillae or even grossly[3] absent 4
2. Spicules relatively short (less than 0.25 mm.) and stout ..... *Aelurostrongylus*
   Spicules long (more than 0.3 mm.) and capillary 3
3. Bursa with all rays of more or less proportionate size ..... *Angiostrongylus*
   Bursa with externolateral rays greatly reduced ..... *Gurltia*
4. Papillary rays not clearly evident; spicules tiny (less than 0.05 mm.) and delicate ..... *Parafilaroides*, gen. nov.
   Papillary rays clearly evident; spicules short to long (more than 0.05 mm.) and stout 5
5. Papillary rays grouped together in typical strongyline pattern ..... *Filaroides*
   Papillary rays strung out on either side of posterior end in no particular pattern ..... *Metathelazia*

In the Carnivora also occur certain genera of lungworms which belong to the subfamily Skrjabingylinae Skriabin, 1933, of the family Trichostrongylidae Leiper, 1912 namely *Crenosoma* Molin, 1861 (in canids, mustelids, and procyonids), *Bronchostrongylus* Cameron, 1931 (in felids), *Otostrongylus* de Bruyn, 1933 (in pinnipedes), etc. These skrjabingylin lungworms can be readily distinguished from the filaroidins by the fact that the vulva in the female opens in the middle section of the body in the former and just in front of the anus in the latter. In a recent paper (Dougherty, 1945) I have presented in some detail the basis for referring the lungworm genera mentioned to the Trichostrongylidae instead of to the Metastrongylidae where all recent workers have placed them.

In the following list I am treating the genera *Parafilaroides*, *Aelurostrongylus*, *Angiostrongylus*, and *Gurltia* in the same way the genera *Filaroides* and *Meta-*

[3] By "grossly" is meant "in the unsectioned worm."

thelazia have already been treated. That is, the first four genera are listed with their synonyms and genotypes, and under each genus are given its species with their synonyms and type hosts. Where generic or trivial names are here reduced to synonymy for the first time, the name in question is indicated with an asterisk [*]. In all cases works in which the original naming of the several genera and species and the forming of new combinations occurred are included in the list

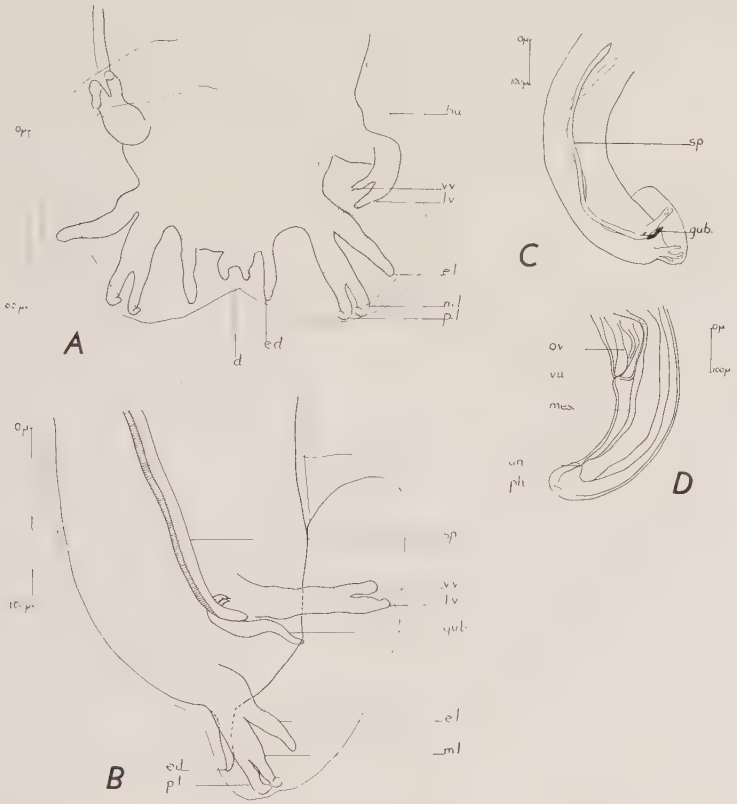

FIG. 2. A—*Angiostrongylus gubernaculatus*, sp. nov.; ventral view of bursa of male. B—*A. gubernaculatus;* lateral view of male posterior end; high magnification. C—*A. gubernaculatus;* lateral view of male posterior end showing spicules; low magnification. D—*A. gubernaculatus;* lateral view of female posterior end. *an.*, anus; *bu.*, bursa; *d.*, dorsal ray; *e.d.*, externodorsal ray; *e.l.*, externolateral ray; *gub.*, gubernaculum; *l.v.*, lateroventral ray; *mes.*, mesenteron; *m.l.*, mediolateral ray; *ov.*, ovejector; *ph.*, phasmid; *p.l.*, posterolateral ray; *sp.*, spicule; *vu.*, vulva; *v.v.*, ventroventral ray. Drawings in figure 2 made with the aid of the camera lucida.

of references; and other important works are cited in the following text and are to be found in the list of references. In addition, a diagnosis is presented for the new genus *Parafilaroides*, and under *Angiostrongylus* there is the description of a new species—*Angiostrongylus gubernaculatus*, sp. nov., from the California badger (*Taxidea taxus neglecta*) (type host) and the Holzner striped skunk (*Mephitis mephitis holzneri*).

Filaroidinae Skriabin, 1933; (see also: Chandler, 1931; Shul'ts, Orlov, and Kutas, 1933; Böhm and Gebauer, 1934; Yamaguti, 1941.)

SYNONYMY.—Filariopsidae Chandler, 1931 (family); *Angiostrongylea Shul'ts, Orlov, and Kutas, 1933 (subsubfamily); *Angiostrongylinae Böhm and Gebauer, 1934; *Cardionematinae Yamaguti, 1941.

TYPE GENUS.—*Filaroides* v. Beneden, 1858, (7 species).

OTHER GENERA.—*Metathelazia* Skinker, 1931 (5 species); and:

Parafilaroides,[4] gen. nov.

SYNONYMY.—*Filaroides* v. Beneden, 1858 (partim).

DIAGNOSIS.—Filaroidinae; small worms, thread-like with delicate cuticle; stoma vestigial. *Male:* bursa completely lacking and, when posterior end is studied in the unsectioned worm under the microscope, only a pair of terminal papillae, apparently representing rays, are evident; spicules tiny (less than 0.05 mm. long), equal, and delicate; gubernaculum present. *Female:* ovoviviparous with terminal parts of uteri filled with embryos; ovejector short and characteristic of Metastrongylidae; vulva marked by a clear, valve-like structure similar to that found in *Metathelazia*. In carnivores of the suborder Pinnipedia (so far found in seals and sea-lions only).

GENOTYPE.—*P. gymnurus* (Railliet, 1899), comb. nov.

NOTE.—This genus is close to *Filaroides*, but the extreme delicacy and small size of its spicules and the very degenerate nature of the male posterior end set it off by itself. The diagnosis given here is in part based on study of *Parafilaroides* spp. from sea-lions, descriptions of which are now in preparation.

SPECIES.—

Parafilaroides gymnurus (Railliet, 1899), comb. nov.; (see also: Baylis and Daubney, 1925; Dougherty, 1943.)

SYNONYMY.—*Pseudalius gymnurus* Railliet, 1899; *Halocercus gymnurus* (Railliet, 1899) Baylis and Daubney, 1925; *Filaroides gymnurus* (Railliet, 1899) Dougherty, 1943.

TYPE HOST.—Common harbor seal, *Phoca v. vitulina* Linné.

Parafilaroides spp.; (see Herman, 1942; Dougherty, 1943.)

SYNONYMY.—*Halocercus* sp., of Herman, 1942; *Filaroides* spp., of Dougherty, 1943.

HOSTS.—California sea-lion, *Zalophus californianus* (Lesson) (one species); Steller sea-lion, *Eumetopias jubata* (Schreber) (two species).

Aelurostrongylus Cameron, 1927; (see also; Wetzel, 1938.)

SYNONYMY.—*Perostrongylus* Schlegel, 1933; **Pulmostrongylus* Hsü, 1935.

GENOTYPE.—*A. abstrusus* (Railliet, 1898) Camerson, 1927.

SPECIES.—

Aelurostrongylus abstrusus (Railliet, 1898) Cameron, 1927; (see also: Mueller, 1890; Railliet and Henry, 1907; Braun and Lühe, 1909.)

SYNONYMY.—*Strongylus pusillus* Mueller, 1890 (*nec* Rudolphi, 1803); *Strongylus abstrusus* Railliet, 1898; *Synthetocaulus abstrusus* (Railliet, 1898) Railliet and Henry, 1907; **Strongylus nanus* Braun and Lühe, 1909; *Metastrongylus pusillus* (Mueller, 1890) Sluiter and Swellengrebel, 1912.

TYPE HOST.—Domestic cat, *Felis catus* Linné.

Aelurostrongylus falciformis (Schlegel, 1933) Wetzel, 1938; (see also: Schlegel, 1934; Böhm and Gebauer, 1934; Wetzel, 1937.)

SYNONYMY.—*Strongylus falciformis* Schlegel, 1933; *Perostrongylus*

[4] From παρά, beside; and *Filaroides*.

falciformis (Schlegel, 1933) Schlegel, 1934; *Filaroides falciformis* (Schlegel, 1933) Wetzel, 1937.

TYPE HOST.—Common European badger, *Meles m. meles* (Linné).

Aelurostrongylus fengi (Hsü, 1935), comb. nov.

SYNONYMY.—*Pulmostrongylus fengi* Hsü, 1935.

TYPE HOST.—Crab-eating mongoose, *Herpestes urva* Hodgson.

Aelurostrongylus brauni (v. Linstow, 1897), comb. nov.

SYNONYMY.—*Strongylus brauni* v. Linstow, 1897.

TYPE HOST.—Indian civet, *Viverra zibetha* (Linné) (subsp. ?).

NOTE.—This species may represent a distinct genus if the extreme fusion of rays indicated in the figures given by von Linstow (1897) is accurately represented. However, von Linstow's illustrations in his many works are uniformly somewhat schematic, and *A. brauni* should be restudied before any further action is taken.

Angiostrongylus Kamenskiĭ, 1905; (see also: Railliet and Henry, 1907; Leiper, 1926.)

SYNONYMY.—*Haemostrongylus* Railliet and Henry, 1907; **Parastrongylus* Baylis, 1928; **Rodentocaulus* Shul'ts, Orlov, and Kutas, 1933; **Pulmonema* Chen, 1935; ?**Cardionema* Yamaguti, 1941 (*nec Cardianema* Alicata, 1933).

GENOTYPE.—*A. vasorum* (Baillet, 1866) Kamenskiĭ, 1905.

SPECIES.—

Angiostrongylus vasorum (Baillet, 1866) Kamenskiĭ, 1905; (see also: Serres, 1854; Bossi, 1871; Railliet and Henry, 1907; Leiper, 1926.)

SYNONYMY.—*Strongylus vasorum* Bailliet, 1866; *ematozoa filaria cardiaca*, of Bossi, 1871; *Strongylus vasorum kanis* Schneidemühl, 1896; *Strongylus vasorum canis* Vogel in Guittard, 1899; *Angiostrongylus cardiacus* Bossi, of Kamenskiĭ, 1905; *Haemonchus vasorum* (Baillet, 1866) Sluiter and Swellengrebel, 1912; *Haemostrongylus vasorum* (Baillet,1866) Neveu-Lemaire, 1912; *Strongylus* (*Haemostrongylus*) *vasorum*, of Hutyra and Marek 1913.

TYPE HOST.—Domestic dog, *Canis familiaris* Linné.

NOTE.—Leiserung (1865) described nematodes from the venus sinus in the penis of a dog under the new name "*Haematozoon*" *subulatum*. He erroneously identified them as the same form previously observed by him from nodules in the lungs of another dog; the latter were undoubtedly specimens of *Filaroides osleri* (Cobbold, 1879) Skriabin, 1933. A number of workers, beginning with Cobbold (1873) have considered that Leiserung observed *A. vasorum;* and Stiles and Baker (1935) in their catalogue of parasites in the Carnivora have listed *Haematozoon subulatum* under the genus *Haemostrongylus* (= *Angiostrongylus*) as a bracketed entry, *i.e.*, one for which a new combination of *subulatum* with *Haemostrongylus* was not intended by them. However, examination of Leiserung's figures and description reveal the fact that his *H. subulatum* was not a strongyline at all, but a rhabditine, and, since the dog had been dead for ten days when autopsied, the worm probably represented a post-mortem contaminant.

Angiostrongylus raillieti (Travassos, 1927), comb. nov.

SYNONYMY.—*Haemostrongylus raillieti* Travassos, 1927.

TYPE HOST.—Crab-eating dog, *Dusicyonhous azarae* (Wied).

NOTE.—This species is quite likely the same as *A. vasorum*.

Angiostrongylus gubernaculatus[5] sp. nov. (Fig. 2.)

DIAGNOSIS.—*Male* (4 specimens): 18 to 19.5 mm. long, 300 μ in maximum width; oesophagus 300 to 335 μ long; bursa well developed with normal complement of rays, dorsal lobe reduced; rays relatively long, except for dorsal; ventro- and lateroventral rays largely fused; medial rays arising in a common trunk; medio- and posterolateral rays largely fused; dorsal ray short, broad, and terminating in two short branches; spicules essentially equal, 520 to 560 μ long, capillary, and provided with striated alae; gubernaculum present, sometimes slightly projecting through anus, 45 to 50 μ long, and consisting of two proximal, lateral branches which come together and fuse near the anus, each branch being shaped like a fish-hook with the open side of the hook directed ventrally. *Female* (4 specimens): 22 to 24 mm. long, 350 μ in maximum width; oesophagus 335 to 350 μ long; vulva preanal in position, 205 to 250 μ from anus; anus 75 to 90 μ from posterior end; oviparous.

TYPE HOST.—California badger, *Taxidea taxus neglecta* Mearns.

OTHER HOST.—Holzner striped skunk, *Mephitis mephitis holzneri* Mearns.

LOCATION.—"Heart" (? right ventricle).

GEOGRAPHICAL DISTRIBUTION.—California (type locality: Pine Valley, near Hastings Natural History Reservation, Monterey County).

TYPE SPECIMENS.—Holotype male, U. S. Nat. Mus. Helm. Coll. No. 36934; allotype female, U. S. Nat. Mus. Helm. Coll. No. 36935; paratypes, in collections of the Hastings Natural History Reservation.

NOTE.—*Angiostrongylus gubernaculatus* differs from all other species of its genus—at least in so far as they have been described—by the possession of a gubernaculatum. This difference is not, I believe, of generic importance in metastrongylids with simple gubernacula, such as the Filaroidinae and Metastrongylinae. In addition the bursal rays of *A. gubernaculatus*, although in part fused into groups, are apparently longer and better developed than in the other members of the genus. In certain respects *A. gubernaculatus* tends to bridge the gap between *Angiostrongylus* and *Gurltia*, for both this species and *Gurltia paralysans*, type and only species of *Gurltia*, possess gubernacula, and the long, largely fused ventral and medio-posterolateral ray groups in the former resemble what appear to be these same groups in the latter. However, in *G. paralysans*, if one may judge by Wolffhügel's figures (1934), there seems to have occurred a degenerative evolutionary process affecting the externo-lateral rays at least; and therefore for the present I prefer to keep these two genera separate.

Angiostrongylus tateronae (Baylis, 1928), comb. nov.

SYNONYMY.—*Parastrongylus tateronae* Baylis, 1928.

TYPE HOST.—Kemp jerboa, *Tatera kempii* Wroughton.

Angiostrongylus cantonensis (Chen, 1935), comb. nov. (see also: Yokogawa, 1937).

SYNONYMY.—*Pulmonema cantonensis* Chen, 1935; **Haemostrongylus ratti* Yokogawa, 1937.

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[5] Type material (from the badger) collected by Dr. J. M. Linsdale, Director of the Hastings Natural History Reservation, on July 3, 1944. Other specimens (from the skunk) collected by Dr. Linsdale on December 20, 1944, and October 10, 1945.

SYNTYPE HOSTS.—Norway rat, *Rattus norvegicus* (Erxleben); common house rat, *Rattus r. rattus* (Linné).

Angiostrongylus ondatrae (Shul'ts, Orlov, and Kutas, 1933), comb. nov.

SYNONYMY.—*Rodentocaulus ondatrae* Shul'ts, Orlov, and Kutas, 1933.

TYPE HOST.—Muskrat, *Ondatra zibethica* (Linné) (?subsp.).

(?) Angiostrongylus ten (Yamaguti, 1941), comb. nov.

SYNONYMY.—*Cardionema ten* Yamaguti.

TYPE HOST.—Common black-footed marten, *Martes m. melempus* (Wagner in Schreber).

Gurltia Wolffhügel, 1933 (see also Wolffhügel, 1934).

GENOTYPE.—*G. paralysans* Wolffhügel 1933.

SPECIES.—

Gurltia paralysans Wolffhügel, 1933 (see also Wolffhügel, 1934).

SYNTYPE HOSTS.—Domestic cat, *Felis catus* Linné; spotted tiger cat, *Felis g. guigna* Molina.

SUMMARY

The subfamily Filaroidinae Skriabin, 1933, of the family Metastrongylidae Leiper, 1909, has six genera: *Filaroides* v. Beneden, 1858 (genotype; 7 species); *Metathelazia Skinker*, 1931 (5 species); *Parafilaroides*, gen. nov. (for *Pseudalius* or *Filaroides gymnurus*); *Aelurostrongylus* Cameron, 1927 (4 species); *Angiostrongylus* Kamenskiĭ, 1905 (6 species); and *Gurltia* Wolffhügel, 1933 (1 species). The species of the last four genera are listed with their synonyms and type hosts. A new species, *Angiostrongylus gubernaculatus*, sp. nov., from the heart of the California badger (*Taxidea taxus neglecta*) (type host) and the Holzner striped skunk (*Mephistis mephistis holzneri*), is described.

LIST OF REFERENCES

BAILLET, C. C. 1866. Helminthes. Nouv. Dict. Prat. Méd. Vét. **8**: 519–687. [Also: Histoire naturelle des helminthes des principaux mammifères domestiques. 172 pp. Paris.]

BAYLIS, H. A. 1928. On a collection of nematodes from Nigerian mammals (chiefly rodents). Parasitology **20**(3): 280–394, 25 figs.

————, and DAUBNEY, R. 1925. A revision of the lung-worms of Cetacea. Ibid. **17**(2): 201–216, 25 figs.

BÖHM, L. K., and GEBAUER, O. 1934. Zur System der Familie der Metastrongylidae Leiper, 1908. Zool. Anz. **105**(11/12): 287–294.

BOSSI, G. 1871. Due casi di cardite verminosa prodotta da un particolare entozoa con accessi epilettiformi in due cani da caccia. Gior. Med. Vet. **19**(7): 300–303.

BRAUN, M. G. C. C., and LÜHE, M. F. L. 1909. Leitfaden zur Untersuchung der tierischen Parasiten des Menschen und der Haustiere für Studierende, Ärzte. und Tierärzte. 186 pp., 100 figs. Würzburg.

CAMERON, T. W. M. 1927. Studies on three new genera and some little-known species of the nematode family Protostrongylidae Leiper, 1926. Jour. Helminth. **5**(1): 1–24, 14 figs.

CHANDLER, A. S. 1931. New genera and species of nematode worms. Proc. U. S. Natl. Mus. **78**, Art. 23, 11 pp., 2 pls.

CHEN, H. T. 1935. Un nouveau nématode pulmonaire, *Pulmonema cantonensis*, n. g., n. sp., des rats de Canton. Ann. Parasitol. **13**(4): 312–317, 6 figs.

CHITWOOD, B. G., and CHITWOOD, M. B. 1937. An introduction to nematology. Sect. I, pt. 1, pp. 1–53, 53 figs.

COBBOLD, T. S. 1873. The internal parasites of our domesticated animals; a manual of the entozoa of the ox, sheep, dog, horse, pig, and cat. 114 pp., 28 figs. London.

DAVTIAN, É. A. (*i.e.*, Davtjan, E. A.). 1933. Ein neuer Nematode aus den Lungen der Hauskatze, *Osleroides massino*, nov. sp. Deut. Tierärztl. Wchnschr. **4**(24): 372–374, 5 figs.

Dougherty, E. C. 1943. The genus *Filaroides* van Beneden, 1858, and its relatives: preliminary note. Proc. Helminth. Soc. Wash. **10**(2): 69–74.

————. 1945. A review of the genus *Crenosoma* Molin, 1861 (Nematoda: Trichostrongylidae); its history, taxonomy, adult morphology, and distribution. Ibid. **12**(2): 44–62, 3 figs.

Gebauer, O. 1933. Beitrag zur Kenntnis von Nematoden aus Affenlungen. Ztschr. f. Parasitenk. **5**(3/4): 724–734, 10 figs.

Herman, C. M. 1942. The effect of higueronia on nematodes and nemathelminthic gastric ulcers of California sea-lions. Rev. Med. Trop. y Parasitol. Bact., Clin. y Lab. **8**(4): 45–47.

Hsü, H. F. 1935. A study of some Strongyloidea and Spiruroidea from French Indo-China and of *Thelazia chungkingensis* Hsü, 1933 from China. Ztschr. Parasitenk. **7**(5): 579–600, 31 figs.

Hutyra, F., and Marek, J. 1913. Spezielle Pathologie und Therapie der Haustiere. Vol. 2, Krankheiten der Atmungsorgane, der Verdauungsorgane, des Nervensystems, der Bewegungsorgane und der Haut. 4th Ed. xvi + 1088 pp., 231 figs., 12 pls., Jena.

Kamenskiĭ, S. N. 1905. Sistematicheskoe polozhenie radov Metastrongylus Wost. i Protostrongylus g.n. sredi drugikh Strongylidae. Sbornik Trudov Khar'kov. Vet. Inst. **7**(2): 17–50, 8 figs.

Leiserung, A. G. T. 1865. Über Hämatozoen der Haussäugethiere. Arch. Path. Anat. **33**(1): 111–126, pl. 2.

Leiper, R. T. 1926. On the roundworm genera *Protostrongylus* and *Angiostrongylus* Kamensky. Jour. Helminth. **4**(4): 203–207.

von Linstow, O. F. B. 1897. Zur Systematik der Nematoden nebst Beschreibung neuer Arten. Arch. Mikr. Anat. **49**(3): 608–622, 30 figs.

Molin, R. 1858. Versuch einer Monographie dér Filarien. Sitzber. Akad. der Wiss. Wien, Math.-Nat. Kl. **28**(5): 365–461, 2 pls.

Mueller, A. 1890. Helminthologische Mittheilungen. Deut. Ztschr. Thiermed. **17**(1): 58–70, 1 pl.

Neveu-Lemaire, M. 1912. Parasitologie des animaux domestiques. Maladies parasitaires et bactériennes. ii + 1257 pp. 770 figs., Paris.

Railliet, A. 1898. Rectification de la nomenclature d'après les travaux récents. Rec. Méd. Vét. **75**(5): 171–174.

————. 1899. Sur quelques parasites rencontrés à l'autopsie d'un phoque (*Phoca vitulina* L.). Comp. Rend. Soc. Biol. [Paris] **51**(6): 128–130.

————, and Henry, A. 1907. Sur les variations des strongles de l'appareil respiratoire des mamifères. Ibid. **63**(38): 751–753.

Schlegel, M. 1933. Die Lungenwurmseuche beim Dachse. Berlin Tierärztl. Wchnschr. **49**(22): 341–344, 7 figs.

————. 1934. Idem. II. Ibid. **50**(22): 369–373, 4 figs.

Schneidemühl, G. 1896. Lehrbuch der vergleichenden Pathologie des Menschen und der Haustiere, für Thierärzte, Ärzte, und Studirende. Pt. 2, pp. 209–448. Leipzig.

Serres, —. 1854. Entozoaires trouvés dans l'oreillette droite du coeur, le ventricle corresondant et l' artère pulmonaire du chien. Jour. des Vét. du Midi, Toulouse, ser 2, **7**: 70.

Shul'ts, R. È. S., Orlov, I. V., and Kutas, A. IA. (*i.e.*, Schulz, R. Ed. S. Orlov, I. W., and Kutass, A. I.) 1933. Zur Systematik der Subfamilie Synthetocaulinae Skrj. 1932 nebst Beschreibung einiger neuer Gattungen und Arten. Zool. Anz. **102**(11/12): 303–310, 10 figs.

Skriabin, K. I. (*i.e.*, Skriabine, K. I.) 1933. Sur la position systématique des nématodes du genre *Oslerus* Hall, 1921 Bull. Soc. Zool. France **58**(2): 87–89.

————. 1940. O polozhenie roda *Filariopsis* van Thiel, 1926, v sisteme nematod. Dokl. Akad. Nauk S.S.S.R. **27**(9): 1049–1052. [Also: On the position of the genus *Filariopsis* van Thiel, 1926, in the system of nematodes. Comp. Rend. Acad. Sci. U.R.S.S. **27**(9): 1048–1051.]

————. 1941. O filogeneticheskoĭ vzaimosviazi nematod podklassa Phasmidia. (On the phylogenetic interrelationships of nematodes of the suborder [sic] Phasmidia.) Zoologicheskiĭ Zhurnal **20**(3): 327–340, 1 fig.

Sluiter, C. P., and Swellengrebel, N. H. 1912. De dierlijke parasiten van den mensch en van onze huisdieren. 2nd Ed. xvi + 520 pp., 262 figs., 1 pl. Amsterdam.

Stiles, C. W., and Baker, C. E. 1935. Key-catalogues of parasites reported for Carnivora (cats, dogs, bears, etc.) with their possible public health importance. Natl. Inst. Health Bull. No. 163, pp. 913–1223.

Travassos, L. P. 1927. Nematodeos novos. Bol. Biol. São Paulo, Ser. 1, **6**: 52–61, 6 pls.

Vogel, —. In: Guittard, J. 1899. Le *Strongylus vasorum*. Progrès Vét. **12**(5): 131–133.

Wetzel, R. 1937. Zur Entwicklung des Dachslungenwurmes *Filaroides falciformis* (Schlegel, 1933). Sitzber. Gesell. f. Naturf. Freunde [Berlin], for 1937, (1): 1–3, 1 fig.

———. 1938. Zur Biologie und systematischen Stellung des Dachslungenwurmes. Livro Jubilar do Prof. Lauro Travassos, pp. 531–536, 3 figs.

Wolffhügel, K. 1933. Paraplegia cruralis parasitaria felis, causada por *Gurltia paralysans* nov. gen., n. sp. (Nematodes). Rev. Chilena Hist. Nat. **37**: 190–192.

———. 1934. Paraplegia cruralis parasitaria felis durch *Gurltia paralysans* nov. gen. nov. sp. (Nematoda). Ztschr. Infekt. Hyg. Haustiere **46**(1/2): 28–48, 7 figs.

Yamaguti, S. 1941. Studies on the helminth fauna of Japan. Part 35. Mammalian nematodes II. Japan. Jour. Zool. **9**(3): 409–439, pls. 8–9.

Yokogawa, S. 1937. A new species of namatode found in the lungs of rats *Hemostrongylus* [sic] *ratti* sp. nov. Trans. Nat. Hist. Soc. Formosa (170), v. 27, pp. 247–250, 2 figs.

Errata. Ellsworth C. Dougherty, Department of Zoology, University of California, Berkeley, California.

In certain papers by this writer published during the last three years errors occur which impair their usefulness and accordingly deserve correction. The appropriate changes and additions are listed as follows (minor typographical errors are ignored):

1. Dougherty, E. C. 1943. The genus *Filaroides* van Beneden, 1858, and its relatives: preliminary note. Proc. Helminth. Soc. Wash. **10**(2): 69–74.

(a) *Page 71, line 25,* change: "*Gordius mustelarum* Werner, 1782, of Dujardin, 1844," to read: "*Gordius bronchialis* Werner, 1782, of Dujardin, 1844."

(b) *Page 72, line 5,* omit this line: "1940; ?*Oslerus* sp. Travassos, Pinto, and Muniz, 1926; ?*Oslerus* sp. Trav-."

2. Goble, F. C. and Dougherty, E. C. 1943. Notes on the lungworms (genus *Protostrongylus*) of varying hares (*Lepus americanus*) in eastern North America. Jour. Parasitol. 29(6): 397–404.

(a) *Page 400, figure 6,* lettering should read: "*i.d.*" and "*d.l.* + *d.d.*" instead of "*i.v.*" and "*v.l.* + *v.v.*"

(b) *Page 400, lines 3 to 5,* change: "Fig. 5. Anterior end, en face view: *am.*, amphid, *d.l.* + *d.d.*, dorsolateral + dorsodorsal papillae, *i.d.*, interodorsal papilla (on lip), *i.l.*, interolateral papilla, *i.v.*, interoventral papilla, *l.v.*, lateroventral papilla, *v.l.* + *v.v.*, ventrolateral + ventroventral papilla, *st.*, stoma," to read: "Fig. 5. Anterior end, en face view: *am.*, amphid, *d.l.* + *d.d.*, laterodorsal + dorsodorsal papilla, *i.d.*, internodorsal papilla (on lip), *i.l.*, internolateral papilla, *i.v.*, internoventral papilla, *l.v.*, ventrolateral papilla, *v.l.* + *v.v.*, lateroventral + ventroventral papilla, *st.*, stoma."

3. Dougherty, E. C. 1944a. The correct authorities and dates for various supergeneric names in the nematode suborder Strongylina. Proc. Helminth. Soc. Wash. **11**(1): 37–40.

Page 40, line 2, change: "Subfamily Pseudaliinae Railliet and Henry, 1907," to read. "Subfamily Pseudaliinae Railliet and Henry, 1909."

4. Dougherty, E. C. 1944b. The genus *Metastrongylus* Molin, 1861 (Nematoda: Metastrongylidae). Proc. Helminth. Soc. Wash. **11**(2): 66–73.

Page 70, figures A, B, C, and F, scale is incorrect; as used, it equals approximately 110 μ, not 80 μ.

5. Dougherty, E. C. 1944c. The lungworms (Nematoda: Pseudaliidae) of the Odontoceti. Part I. Parasitology 36(1/2): 80–94.

Page 89, first column, lines 5 to 9 of footnote, add: "from nodules in the lungs of the harbour porpoise" to sentence beginning: "Contrary to statements . . ." so that sentence reads: "Contrary to statements by Baylis & Daubney, v. Siebold (1842) did not attribute the name *Strongylus inflexus pulmonalis* to Eschricht, nor did Eschricht (1841c, d) record *Strongylus vagans* from nodules in the lungs of the harbour porpoise."

6. Dougherty, E. C. 1945a. The nematode lungworms (suborder Strongylina) of North American deer of the genus *Odocoileus.* Parasitology 36(3/4): 199–298.

(a) *Page 201, lettering under figures 1 and 2,* insert: "*ar.* arcus" after "*an.* anus."

(b) *Page 205, second column, lines 35 and 36,* change: "*Odocoileus odocoilei* Hobmaier & Hobmaier" to read: "*Elaphostrongylus odocoilei* Hobmaier & Hobmaier, 1934."

(c) *Page 206, figure 9, labeling,* change second "*al.*" to read "*ar.*"

7. Dougherty, E. C. 1945b. A review of the genus *Crenosoma* Molin, 1861 (Nematoda: Trichostrongylidae); its history, taxonomy, adult morphology, and distribution. Proc. Helminth. Soc. Wash. 12(2): 44–62.

(a) *Page 55, table 1,* under "*C. goblei,* sp. nov." length of oesophagus in female should read "300–330 μ."

(b) *Page 58, lines 29 and 30,* change: "and *Troglostrongylus* Travassos, 1925" to read: "*Troglostrongylus* Vevers, 1922; and *Heterostrongylus* Travassos, 1925."

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

CONSTITUTION

ARTICLE 1

Name

The name of the Society shall be the Helminthological Society of Washington.

ARTICLE 2

Object

The object of the Society shall be to provide for the association of persons interested in parasitology and related sciences for the presentation and discussion of items of interest pertaining to those sciences.

ARTICLE 3

Membership

Section 1. There shall be four classes of members, viz., resident, non-resident, life, and honorary.[1]

Section 2. Any person interested in parasitology or related sciences and residing in or near Washington or Baltimore, may be elected to resident membership in the Society. The privileges and responsibilities of resident members are set forth in the By-Laws.

Section 3. Any person of similar interest, and not residing in or near Washington or Baltimore, may be elected to non-resident membership in the Society.

[1] Existing American and Foreign Corresponding Members shall be retained in in these categories, and shall have the privilege, upon payment of dues, of becoming Resident or Non-resident Members of the Society.

The privileges and obligations of non-resident members are set forth in the By-Laws.

Section 4. Any resident or non-resident member who has rendered conspicuous and continuous service to the Society for a period of not less than fifteen years, and has reached the age of retirement, may be elected to life membership. Life members shall have all the privileges of resident members but shall be exempted from payment of dues. The number of life members shall not exceed three at any one time.

Section 5. Any person who has attained eminent distinction in parasitology or related sciences may be elected to honorary membership. An honorary member shall have all the privileges of membership except voting, holding office, or having any interest in the real or personal property of the Society. He shall be exempted from the payment of dues. The number of honorary members shall not exceed ten at any one time and not more than one honorary member shall be elected in any one year.

ARTICLE 4

Officers

Section 1. The officers of the Society shall be a President, a Vice-President, a Recording Secretary, a Corresponding Secretary-Treasurer, and such other officers as the Society may deem necessary. Only members who are in good standing and whose dues are not in arrears shall be eligible for election to office.

Section 2. The President shall preside over all meetings, appoint all committees, except as provided in Article 9, Sections 2 and 5, and Article 10, Sections 1 and 3, of the By-Laws, and perform such other duties as may properly devolve upon a presiding officer. The President shall hold office for one year and shall not be eligible to succeed himself.

Section 3. The Vice-President shall preside in the absence of the President, and, when so acting, shall perform such duties as would otherwise devolve upon the President. The Vice-President shall hold office for one year.

Section 4. In the absence of both President and Vice-President, the member, among those present, who first held the office of President shall be the presiding officer.

Section 5. The Recording Secretary shall record the proceedings of all meetings and shall present at each meeting a written report of the transactions of the preceding meeting, shall keep an accurate and complete record of the business transacted by the Society in its meetings, and shall notify the Corresponding Secretary-Treasurer of the election of new members.

Section 6. The Corresponding Secretary-Treasurer shall prepare all statements of financial obligations owing to the Society, shall handle all funds and collections, and shall pay all bills which the Society owes. This officer shall maintain rolls of the membership in all categories and shall notify members of delinquency in the payment of dues in accordance with provisions of the By-Laws, and shall at the beginning of each year provide the Recording Secretary with a copy of the roll of resident members. At the beginning of each year he shall present to the Society an itemized statement of the receipts and expenditures of the previous year.

ARTICLE 5

Executive Committee

Section 1. There shall be an Executive Committee which shall be the administrative body of the Society.

Section 2. The number of members of the Executive Committee, their duties, terms of office, the method of selecting them and of filling vacancies shall be provided in the By-Laws.

ARTICLE 6

Editorial Committee

Section 1. There shall be an Editorial Committee for the Society's publication, which shall be called The Proceedings of the Helminthological Society of Washington.

Section 2. The number of its members, their duties, terms of office, the method of selecting them and of filling vacancies shall be provided in the By-Laws.

ARTICLE 7

Publication

The Proceedings of the Society shall be published at such times and in such form as the Society through its Editorial Committee may determine.

ARTICLE 8

Meetings

Meetings of the Society shall be held monthly during the months of January, February, March, April, May, October, November, and December, the time and place to be determined by a majority vote of the resident membership.

ARTICLE 9

Amendments to the Constitution

Any amendment to the Constitution shall be presented in writing and shall not be acted upon until the meeting following the meeting at which the amendment was proposed. A majority vote of the resident members shall be required for the adoption of any proposed amendment.

BY–LAWS

ARTICLE 1

Procedure

The rules contained in Robert's *Rules of Order,* Revised, shall govern the Society in all cases to which they are applicable, and in which they are not inconsistent with the By-Laws or the special rules of order of this Society.

ARTICLE 2

Order of Business

Call to order.
Reading of minutes of previous meeting.
Election of new members.
Reports of committees.
Unfinished business.
New business.
Presentation of notes and papers.

ARTICLE 3

Election of Members

Section 1. Candidates for election to resident or non-resident membership may be sponsored and proposed only by members in good standing. The candidate shall submit a duly executed and signed application to the Recording Secretary, who in turn shall submit the application to the Executive Committee. The Committee shall review the application and submit its findings to the Society. Voting may be either *viva voce* or by ballot. The Corresponding Secretary-Treasurer shall inform the candidate of the action of the Society.

Section 2. Payment of dues shall be considered as evidence of acceptance of membership in the Society. Election to membership shall be void if the person elected does not pay his dues within three months after the date of notification of election.

ARTICLE 4

Nomination and Election of Officers

Section 1. The Executive Committee, acting as the officer-nominating committee of the Society, shall prepare a slate of officers and present this to the Society at the November meeting of each year. Independent nominations may be made in writing by any five members. In order to receive consideration, such nominations must be in the hands of the Recording Secretary at the time of the election at the December meeting.

Section 2. The last order of business at the December meeting of each year shall be the election and installation of officers. Voting may be either *viva voce* or by ballot.

ARTICLE 5

Meetings

Notice of the time and place of meetings shall be given by the Corresponding Secretary-Treasurer at least three days before the date of the meeting.

ARTICLE 6

Quorum

Section 1. One-third of the resident membership shall constitute a quorum for the transaction of business, except as provided in Articles 8 and 9 of the Constitution and Articles 7 and 14 of the By-Laws. The opinions of the members on any changes in matters covered by these Articles shall be obtained by the Recording Secretary by ballot.

Section 2. When in attendance at any regular meeting, non-resident members shall be considered as resident members for the purpose of determination of quorum and for balloting.

ARTICLE 7

Dues and Debts Owed to the Society

Section 1. The annual dues for resident members shall not exceed five dollars, the actual amount to be determined by the needs of the Society. Any change in the amount of dues shall be effected only by the majority vote of the resident members.

Section 2. The dues for non-resident and resident members shall be identical, unless and until the Executive Committee, in which the authority is hereby vested, shall fix the dues for non-resident members at a rate differing from the dues for resident members.

Section 3. The fiscal year for payment of dues and for all other business purposes shall be the same as the calendar year, that is, from January 1 to December 31, and dues shall be payable on January 1. The dues of a newly elected member paid prior to July 1 of the year of his election shall be credited to that year; if paid after July 1, they shall be credited either to the current fiscal year or to the following one, at the option of the new member. The dues shall include subscription to the Society's publication.

Section 4. All other obligations owed to the Society by members or non-members shall be due and payable thirty days after bills are rendered; the further extension of credit to those whose obligations are in arrears shall be a matter for decision by the Executive Committee.

ARTICLE 8

Suspension and Reinstatement

Any member whose dues are in arrears for one year shall be suspended from membership. Suspension shall be effective thirty days after a notification of the impending suspension shall have been mailed to his last address. The Corresponding Secretary-Treasurer shall remove the name of the delinquent member from the roll and shall notify the Recording Secretary of the removal. Suspended members may be reinstated automatically upon payment of the dues in arrears and the dues for the current fiscal year, or may be otherwise reinstated by action of the Executive Committee.

ARTICLE 9

Editorial Committee

Section 1. The Editorial Committee shall consist of five members in good standing. To the fullest practicable degree they shall represent the varied scientific interests and the employment-group affiliations of the Society's membership.

Section 2. The term of membership on the Editorial Committee shall be five years, and one member of the Committee shall be elected annually in December by the Society, upon nomination by the Editorial Committee.

Section 3. The Committee shall hold a regular meeting annually in November and shall meet at such other times as may be designated by the Chairman. The Chairman shall be chosen by the Committee.

Section 4. The Committee shall choose one of its members to serve as Editor of the Society's publication. The Committee shall be charged with formulating the publication policies and shall make all decisions with respect to the format and content of the publication. Agreement of three members shall be sufficient to render decisions of the Committee effective.

The Editor and at least one other member of the Committee shall review each note or paper to be published.

Section 5. Vacancies on the Committee shall be filled for the unexpired term by election by the Society, upon nomination by the Editorial Committee.

ARTICLE 10

Executive Committee

Section 1. The Executive Committee shall consist of six resident members in good standing as follows: The President of the Society (*ex officio*), the Recording Secretary (*ex officio*), the Corresponding Secretary-Treasurer (*ex officio*), the Editor of the Society's publication, and two members-at-large. The Committee shall represent to the fullest practical degree the varied scientific interests of the Society's membership and the local distribution of its resident members.

Section 2. The President shall serve as Chairman of the Executive Committee.

Section 3. Members-at-large shall serve for terms of two years. A member-at-large shall be appointed each year in January by the President for the prescribed term of two years, and the appointment shall be subject to ratification by the Society.

Section 4. Vacancies occurring on the Executive Committee for any reason shall be filled by appointment by the President of the Society, the appointee to serve for the remainder of the unexpired term of the member in whose place he is appointed.

Section 5. The Executive Committee shall be charged with the duty of carrying out the provisions of the Constitution and By-Laws and shall be empowered to make decisions on all matters of general and financial policy not otherwise set forth in the Constitution and By-Laws and shall make a report of its actions to the Society annually at the last regular meeting.

Section 6. It shall approve the selection of a depository for the current funds, direct the investment of the permanent funds and act as the administrative body of the Society on all matters involving finance, except the disposition of money in the general fund. It shall prepare and present to the Society at the beginning of each calendar year a budget based on the estimated receipts and expenditures of the coming year with such recommendations as may seem desirable.

Section 7. With the presentation of the annual budget the Executive Committee shall present to the Society, if feasible, the estimated cost for publication to be charged to contributors to the Society's publication for that year.

Section 8. Cost of publication, in excess of the amounts borne by the Society, shall be equitably distributed by the Executive Committee among the contributors.

Section 9. It shall pass on the eligibility of all applicants proposed for membership and on the reinstatement of delinquent members, except as otherwise provided, and shall make its recommendations to the Society.

Section 10. It shall present to an auditing committee annually the accounts of all officers having charge of funds and property of the Society and report the results of the audit to the Society.

ARTICLE 11

Establishment of Funds

Section 1. All sums in the Treasury on December 31, 1943 and all sums owing to the Society as of that date, if and when collected, shall be placed in or allocated to a fund to be known as the Publication Fund. This fund shall embrace the five 100-dollar Series G, U. S. bonds owned by the Society on December 31, 1943. This Fund shall not contain less than five hundred dollars or its equivalent in securities.

Section 2. One dollar from the dues of each resident member, except as provided above, shall be placed in a second fund to be known as the General Fund; all other income of the Society shall be placed in the Publication Fund.

ARTICLE 12

Uses of Funds

Section 1. Money in the Publication Fund shall be available exclusively to defray the cost of publishing and distributing the Society's publication and to activate plans to increase its circulation. Income from the investment of the five hundred dollar reserve of this Fund, created under Article 11, Section 1, and from the Fund as a whole shall be available for the same purposes. In the event of temporary discontinuation of the Society's publication, income from the investment of this Fund and all sums allocated to it under the provisions of Article 11, Section 2 shall accrue until resumption of publication is deemed feasible.

Section 2. Money in the General Fund shall be available to defray all routine operating expenses of the Society, exclusive of those connected with the Society's publication, and may be utilized for such special purposes as may be authorized by the Society. The Society may authorize the transfer of money from this Fund to the Publication Fund.

ARTICLE 13

Provision for Dissolution of Funds

In the event it is determined permanently to discontinue the Society's publication, all sums in the Publication Fund shall revert to the General Fund. In the event the Society is disbanded, all sums in the General Fund shall be presented to the Trustees of the Ransom Memorial Fund for such purposes as that continuing body may deem advisable.

ARTICLE 14

Amendments to the By-Laws

Any amendment to these By-Laws shall be presented in writing and shall not be acted upon until the meeting following the meeting at which the amendment was proposed. The votes of a majority of the resident members shall be required for the adoption of any amendment.

Report of the Brayton H. Ransom Memorial Trust Fund
December 31, 1945

STATEMENT FOR THE YEAR 1944:	
ON LOAN, Jan. 1, 1944	$1400.00
BALANCE ON HAND, Jan. 1, 1944	126.86
RECEIPTS:	
Semi-annual interest on loan @ $28	56.00
Interest on bank account	1.24
TOTAL RECEIPTS	$ 184.10
DISBURSEMENTS:	
Rent, safe deposit box	$ 4.20
Award to Proceedings Helminthological Society of Washington	25.00
TOTAL DISBURSEMENTS	$ 29.20
BALANCE ON HAND, Dec. 31, 1944	154.90
	$ 184.10
STATEMENT FOR THE YEAR 1945:	
ON LOAN, Jan. 1. 1945	$1400.00
BALANCE ON HAND, Jan. 1, 1945	154.90
RECEIPTS:	
Semi-annual interest on loan @ $28	56.00
Interest on bank account	1.52
Repayment of loan	1400.00
TOTAL RECEIPTS	$1612.42
DISBURSEMENTS:	
Rent, safe deposit box	$ 4.20
Award to Proceedings Helminthological Society of Washington	25.00
As loan @ 4% interest	1400.00
TOTAL DISBURSEMENTS	$1429.20
BALANCE ON HAND, Dec. 31, 1945	183.22
	$1612.42

Meetings of the Trustees were held May 13, 1944, and May 19, 1945.

Eloise B. Cram,
Secretary-Treasurer

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